California Emergency Medical Services Information System and Trauma Data Linkage Initiative: Emergency Medical Services Authority Preventive Health and Health Services Block Grant

Emergency Medical Services Authority
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Introduction

Under the provisions of the Preventive Health and Health Services Block Grant (PHHSBG), this is the California Emergency Medical Services (EMS) Authority's attempt to link robust prehospital and hospital data and create a path forward for future research and policy-making decisions. This is part one of two briefs on identifying which criteria affects the variable outcomes and the efficacy of matching data. One goal of this project is to compare methods of capturing and linking EMS patient record data from the California Emergency Medical Services Information System (CEMSIS) repository and the Patient Registry. Currently, the EMS Authority does not have access to common or unique identifiers that are normally used in data matching. Thus, we determined that the variables (date of incident and date of birth) were the next best variables for identifying patients across databases. This brief demonstrates how using various data elements and minimal criteria affects how much data and records are matched.

Falls are one major cause for traumatic injuries in general, so we examined this subpopulation further. The EMS Authority collected information on the matched patients to identify the ways in which potential fall injuries were documented by EMS and the trauma hospitals that treat them.

Purpose

1. Provide summary statistics for EMS and trauma-matched records and outcomes of care.
2. Identify a sample population where each patient has an EMS record linked to a hospital record.
3. Analyze the population through various statistics.
4. Summarize results and their implications for further research regarding EMS and other data linkage opportunities.
5. Display data geographically through the Esri ArcGIS Pro™ image and data analysis.

Background

Accidents and traumatic injury are among the leading causes of death in the United States. Between January 1, 2019, and December 31, 2019, there were approximately 98,127 trauma-related incidents recorded in California's trauma patient registry. This number is raw and unclean, so there is a likelihood for

duplicate records. However, when you set criteria such as "date of birth is not blank", it is easier to filter out duplicates and get a more accurate patient count by date of incident, date of birth, and which hospital recorded the patient.

To better understand the matching process and history of CEMSIS data and the trauma patient registry that the EMS Authority is utilizing for patient record linkage research, please refer to the previous report CEMSIS-and-Trauma-Data-Matching-Project.pdf (ca.gov). Until we can find and utilize a unique identifier across databases, the EMS Authority will continue to attempt to match records using variables like birth and incident dates and follow with manually matching records that are probable matches. The EMS Authority is investigating the reasons and patterns as to why records match and others do not by using limiting or nonlimiting criteria for each database.

Methodology

The following information in this report is an overview of how EMS and trauma data were linked and what the results and data analyses look like. The EMS Authority intended to show a representation of the data that were collected and matched with the goal of using this as a starting point for further research. Below is a summary of the process the EMS Authority used to collect, analyze, and present the linked statewide EMS and trauma data for January 1, 2019 through December 31, 2019.

Step One

The reports for this project were from CEMSIS using National Emergency Medical Services Information System (NEMSIS) data guidelines version 3.4. The EMS Authority did not filter data variables to obtain the largest population sample possible. For example, there were emergent and non-emergent EMS records that matched in the instance a "traumatic" event was still indicated in the patient trauma registry. There can be "walk-ins" or transfers from another hospital that match with an EMS record. Limiting these types of criteria may hinder obtaining the largest match rate possible. One potential question posed is whether limiting criteria affects match rates.

As mentioned in the previous matching report, EMS Authority staff attempted to find a unique identifier that would yield the highest match rate possible for EMS and trauma records. Ideally, criteria like first and last names, dates of birth, and Social Security numbers are the most unique, but only dates of birth were accessible across these two databases. Oftentimes first responders do not have access to or document their patient's personal information. The EMS Authority determined that the incident date and patient's date of birth were the only viable data elements for these databases regardless of other criteria or parameters. Once those matches were made, staff reviewed the data

manually to find more "probable" matches if there was an error in the dates data for example. The following are the additional criteria and data elements that were used to query the sample population.

Outline: CEMSIS EMS and Patient Registry Trauma Variables

1. Selected timeframe: January 1, 2019 through December 31, 2019
2. Selected inclusion criteria for CEMSIS transactional report:
    a. Incident date is not blank
    b. Date of Birth (DOB) is not blank
    c. Data elements:
        i. Incident date
        ii. Patient date of birth (ePatient.17)
        iii. Patient age (ePatient.15)
        iv. Patient gender (ePatient.13)
        v. Patient race (ePatient.14)
        vi. LEMSA
        vii. Response EMS agency (eResponse.02)
        viii. Situation primary complaint statement (eSituation.04)
        ix. Situation primary provider impression (eSituation.11)
        x. Situation possible injury (eSituation.02)
        xi. Situation initial patient acuity (eSituation.13)
        xii. Situation primary symptom (eSituation.09)
        xiii. Disposition EMS transport method (eDisposition.16)
        xiv. Disposition transport mode from scene (edisposition.17)
        xv. Disposition reason for choosing destination (eDisposition.20)
        xvi. Cause of injury (eInjury.01)
        xvii. Injury trauma center criteria list (eInjury.03)
        xviii. Incident dispatch notified time (eTimes.02)
        xix. Incident unit notified by dispatch time (eTimes.03)
        xx. Incident unit en route time (eTimes.05)
        xxi. Incident unit arrived on-scene time (eTimes.06)
        xxii. Incident unit left scene time (eTimes.09)
        xxiii. Incident unit patient transfer of care time (eTimes.12)
        xxiv. Response type of turnaround delay (eResponse.12)
        xxv. Response type of scene delay (eResponse.10)
        xxvi. Response time: incident unit arrived on-scene minus incident unit notified by dispatch
        xxvii. Scene time: incident unit left scene (eTimes.09) minus incident unit arrived on-scene(eTimes.06)
        xxviii. Ambulance Patient Offload Time (APOT): incident destination transfer of care (eTimes.12) minus incident patient arrived at destination (eTimes.11)

d. Yielded 4,060,821 EMS records for all of 2019 for all reporting EMS agencies and LEMSAs in CEMSIS excluding Los Angeles

3. Selected inclusion criteria for the Image Trend Trauma Patient Registry transactional report
    a. Incident date is not blank
    b. Date of Birth (DOB) is not blank
    c. Data elements:
        i. Incident date
        ii. Patient DOB
        iii. Patient gender
        iv. Patient race
        v. Patient ethnicity
        vi. EMS unit notified time
        vii. EMS unit arrived on-scene time
        viii. EMS unit left scene time
        ix. EMS unit at destination time
        x. Injury Severity Score (ISS) calculated
        xi. ICD-10 injury description
        xii. ICD-10 injury detailed description
        xiii. Trauma type with ICD-10 COI codes
        xiv. Trauma triage criteria (Steps 1 and 2)
        xv. Trauma triage criteria (Steps 3 and 4)
        xvi. ED/Acute care disposition
        xvii. Hospital discharge disposition
        xviii. Facility name
        xix. Transport to your facility
        xx. Probability of survival
        xxi. Ventilator days-total
    d. Produced 311,229 trauma records for all of 2019 in the ImageTrend Patient Registry
4. Duplicates were removed from both, so each patient had one record
        i. Deduplicated CEMSIS EMS records: 2,224,413
        ii. Deduplicated Patient Registry Trauma records: 71,584
5. Generated and exported the reports to Excel as ".csv" files, which were then converted into two ".xlsx" files

Step Two

Matched and queried both tables using SAS

1. Imported both files into SAS Enterprise Guide
2. Linked the tables using an inner join (only incident date and date of birth criteria from both are used in determining matches)

3. 49,654 out of 71,584 hospital records were mapped to EMS records (69% match rate)
4. Exported matched data to Excel to clean and analyze

Step Three
Cleaned and standardized data in Excel

1. Verified records for accuracy and completeness
    a. Manually entered missing or inaccurate ages
    b. Cleaned and abbreviated variable names and record names for brevity
    c. Deleted duplicate columns that were unnecessary
    d. Converted dates and times to be consistent
2. Manually verified if there were more viable matching records
    a. Checked for date transpositions, incorrect or misspelled words, insertions, omissions, etc.

Step Four
Plot data points in a series of maps using ArcGIS Pro visual analytics

1. Identified all LEMSAs in California
2. Identified all trauma hospitals in California (80) and their corresponding trauma level
    a. Identified all trauma hospitals with matched records (60)
    b. Segmented matched records into match rate categories
    c. Identified three main hospital networks for a comparison example (Dignity Health, Sutter Health, and Kaiser Permanente) and assembled them into match rate categories
        i. Indicated if there is a correlation of matched records based on a specific hospital network

Results

All LEMSAs excluding Los Angeles submitted records into CEMSIS for CY 2019 and had at least one patient record match a trauma record. 60 Trauma hospitals submitted records into the Patient Registry for the same timeframe and each one had at least one trauma record match with an EMS patient record. Out of 71,584 trauma records, 49,654 were successfully matched between prehospital (EMS) and hospital (trauma) databases. This yielded a 69% match rate based on the amount of trauma records that were queried from CEMSIS for calendar Year (CY) 2019. EMSA's previous attempt demonstrated a 64% match rate of EMS and trauma records. Although the initial time parameters are different across these two reports (the present one being statewide for all of 2019 and the previous one for only one hospital for six months), the matching metrics are the same and consistent. 69% is a high rate compared to other matching studies that the EMS

Authority reviewed for this project. Below is a sample of metrics for the total population and subpopulation of fall injuries.

Figure 1: Diagram of Successful and Unsuccessful Matched Records with CEMSIS and Patient Registry data

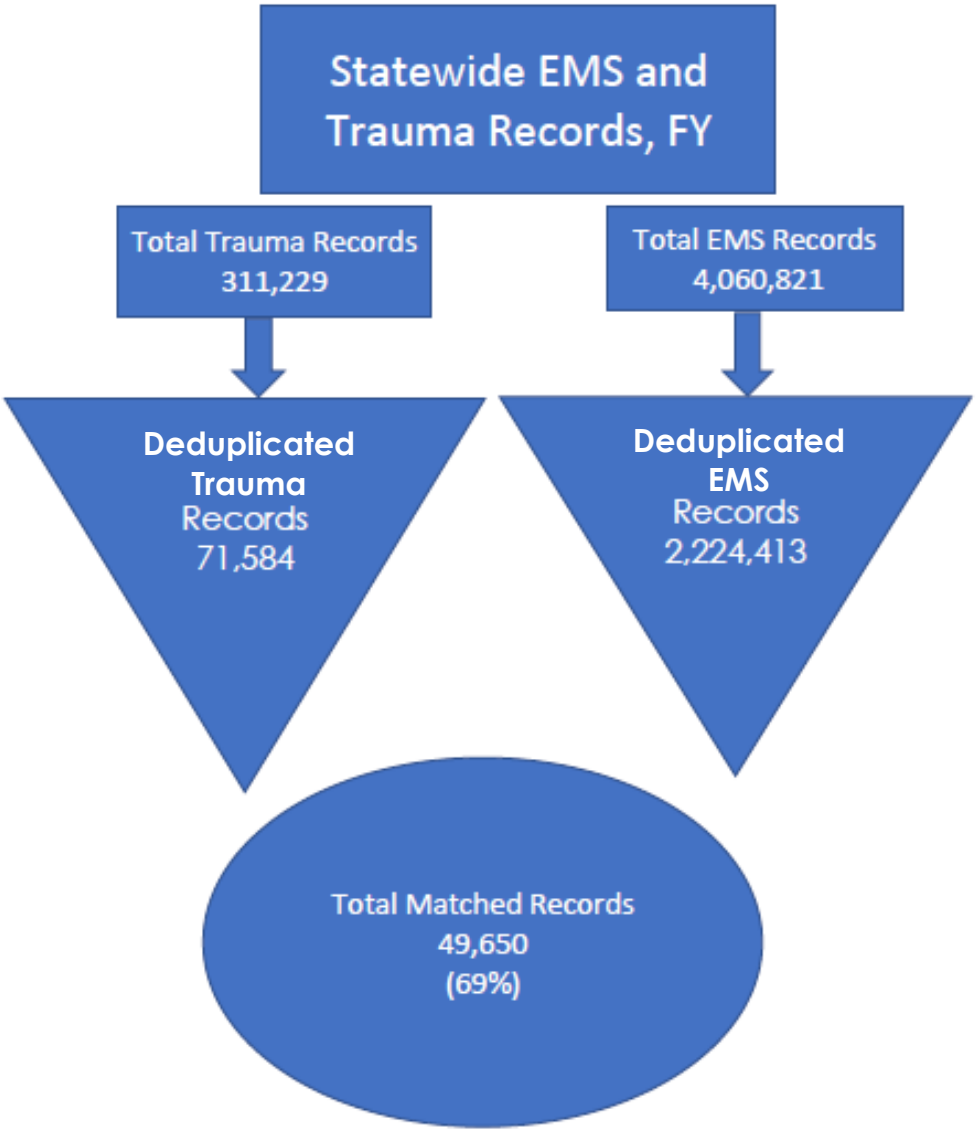


Figure 2: Matched Records Compared to Unmatched Records from EMS CEMSIS Data Matched with Trauma Records

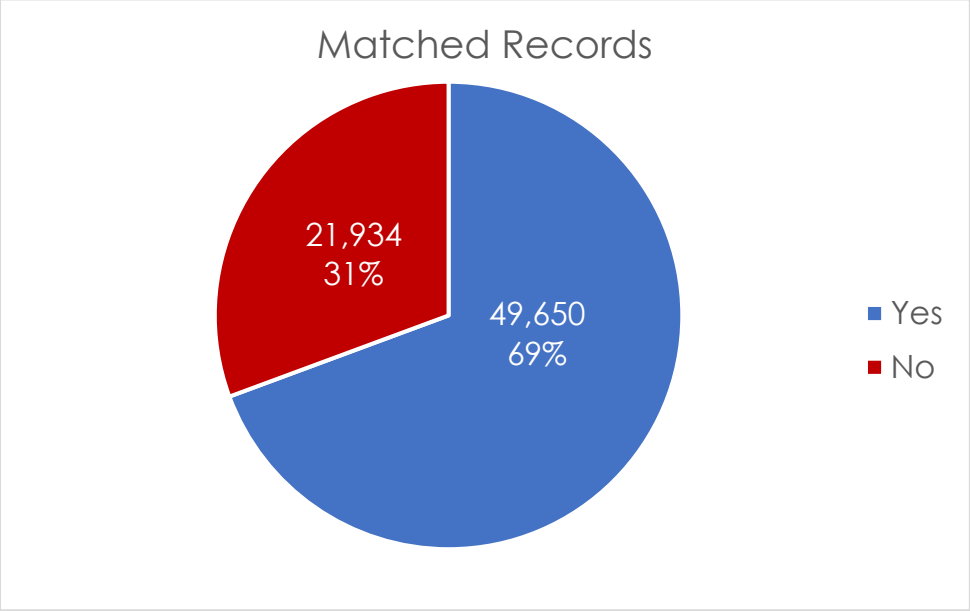
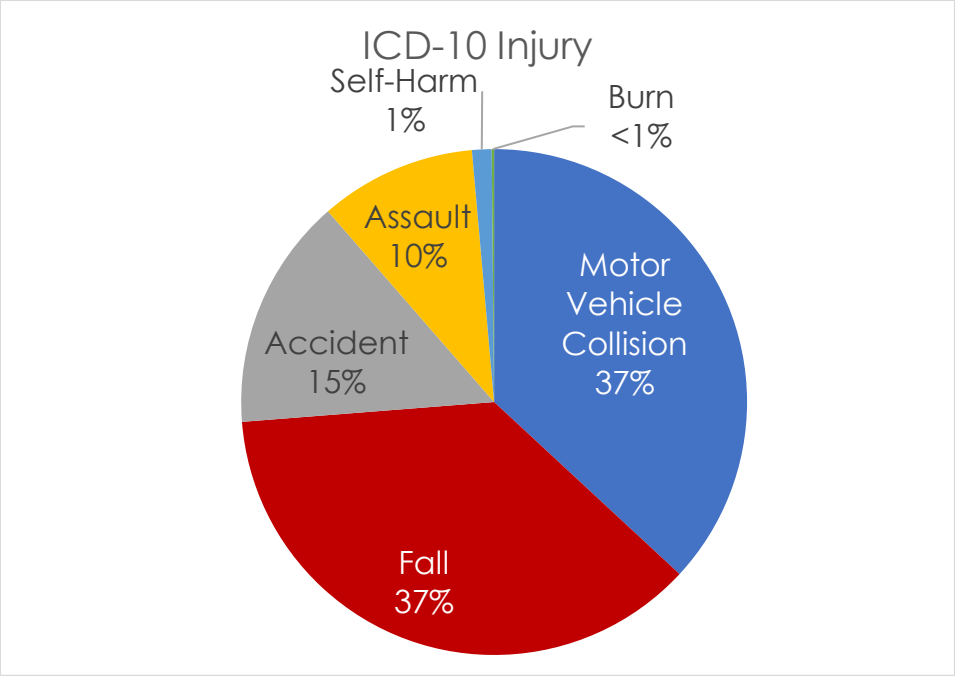
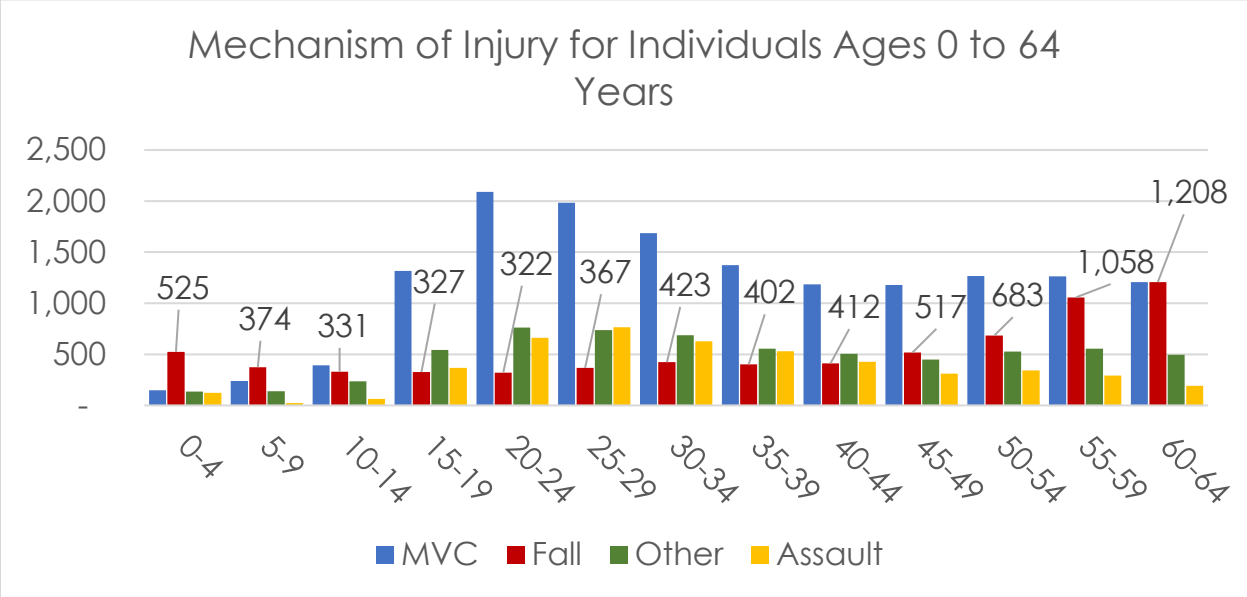


Figure 3: Percent of Patients by ICD-10 Injury Description Category from EMS CEMSIS Data Matched with Trauma Records



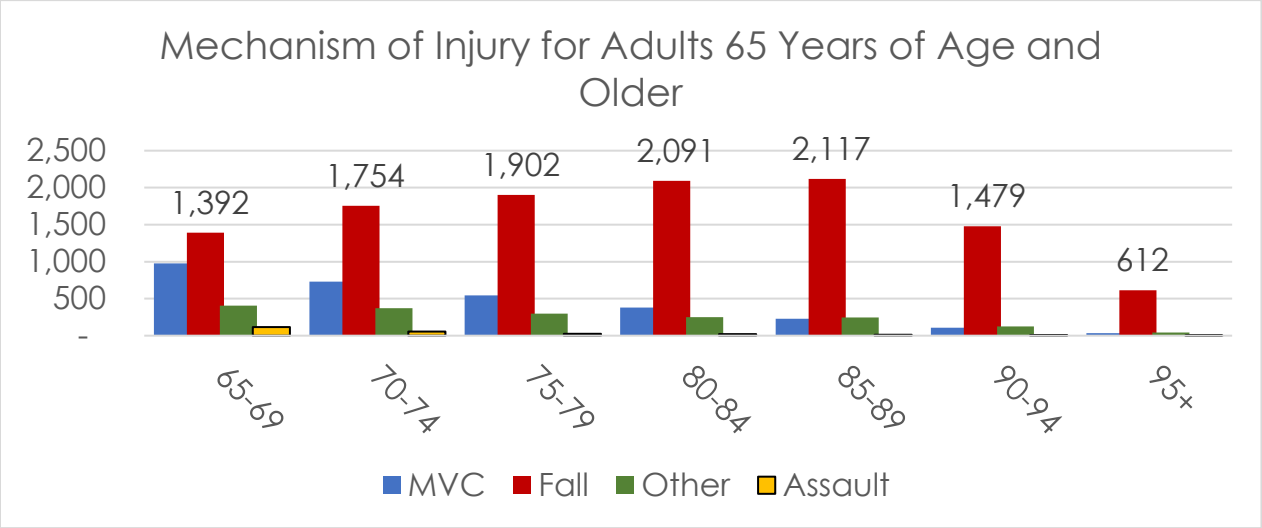
Most injuries were caused by some form of a motor vehicle accident (36.9%)followed closely by 36.8% that pertained to falls.

Figure 4: Mechanism of Injury by Age Category (0 to 64 Years) from EMS CEMSIS Data Matched with Trauma Records



Age is a significant factor with the prevalence of falls as shown below in the 65 years of age or older population. The median is 51 years of age. Out of all records (49,654), 18,296 were identified as a potential fall injury or 36.8%. 11,347 (62%) were 65 years of age or older. Males outpaced females with a potential fall record (52.4% and 47.6% respectively).

Figure 5: Mechanism of Injury by Age Category 65+ Years from EMS CEMSIS Data Matched with Trauma Record



Falls were by far the most common traumatic injury for individuals aged 65 years and older.

Table 1: Count and Percent of Patients by Injury Type from EMS CEMSIS Data Matched with Trauma Records

Injury Type	Count	Percent
Blunt	40,202	80.96%
Blank	5,171	10.41%
Penetrating	3,598	7.25%
Other	562	1.13%
Burn	118	<1%
Drown	2	<1%
Not Known/Not Recorded	1	<1%
Grand Total	49,654	100.00%

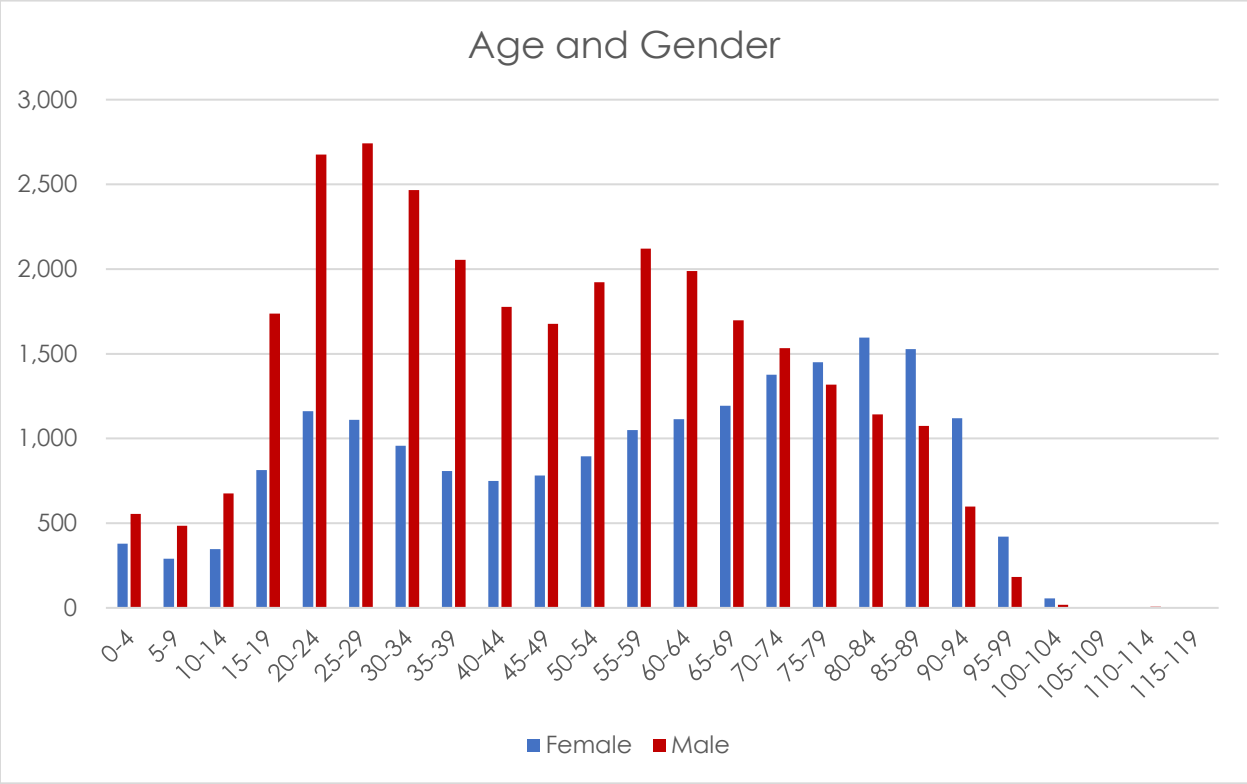
The majority (80%) had a blunt force traumatic injury which is typically found in falls, car accidents, or individuals getting struck by another object or person.

Table 2: Average Travel Times Statewide from EMS CEMSIS Data Matched with Trauma Records

Measure	Minutes
Average Scene Time	**16**
Average Arrival on Scene to Transfer of Care Time	**54**
Average Transport Time	**31**

APOT times were not collected due to a lack of viable data. There was a significant number of negative times and other times that needed clarification. Further investigation and discussion into this issue is merited.

Figure 5: Age and Gender from EMS CEMSIS Data Matched with Trauma Records



Males comprised more than half of the entire population (61%) for this report regardless of the cause of injury. Most reported injuries for males fell between the ages of 20 and 29 (9,939 records or 33% of males). Most females fell between the ages of 70 and 89 (5,950 records or 31%).
The average age of this sample population was 50 years. Most patients were between the ages of 21 and 30 and again between 55 and 74 years of age.

Table 3: Health care systems and their match rates from EMS CEMSIS Data Matched with Trauma Records for CY 2019

Hospital Network	LEMSA	Match Rate Category
Marian Regional Medical Center-Dignity Health	Santa Barbara	31.4%
Mercy Medical Center, Mt. Shasta-Dignity Health	Sierra Sacramento	59.2%
Mercy Medical Center, Redding-Dignity Health	Sierra Sacramento	78.1%
Mercy San Juan Medical Center-Dignity Health	Sacramento	76.1%
Kaiser Permanente, South Sacramento	Sacramento	75.2%
Kaiser Permanente, Vacaville	Solano	60.4%
Sutter Memorial Medical Center, Modesto	Mountain Valley	75.5%
Sutter Coast Hospital	North Coast	63.4%
Sutter Eden Medical Center	Alameda	88.2%
Sutter Lakeside Hospital	North Coast	87.5%
Sutter Roseville Medical Center	Sierra Sacramento	70.6%
University of California, Davis Medical Center	Sacramento	76.6%
University of California, Irvine Medical Center	Orange	78.5%
University of California, San Diego Medical Center	San Diego	26.7%

For this study, there was a 67.6% match rate across four hospital networks totaling 12,485 out of 18,424 records. Individually, Dignity Health Medical Foundation had 66.1% for their four hospitals, Kaiser Permanente had 67.2% for their two hospitals, Sutter Health's hospital network had an overall match rate of 78.2% across their five trauma hospitals, and UC Davis had a rate of 61.1% across their three hospitals.

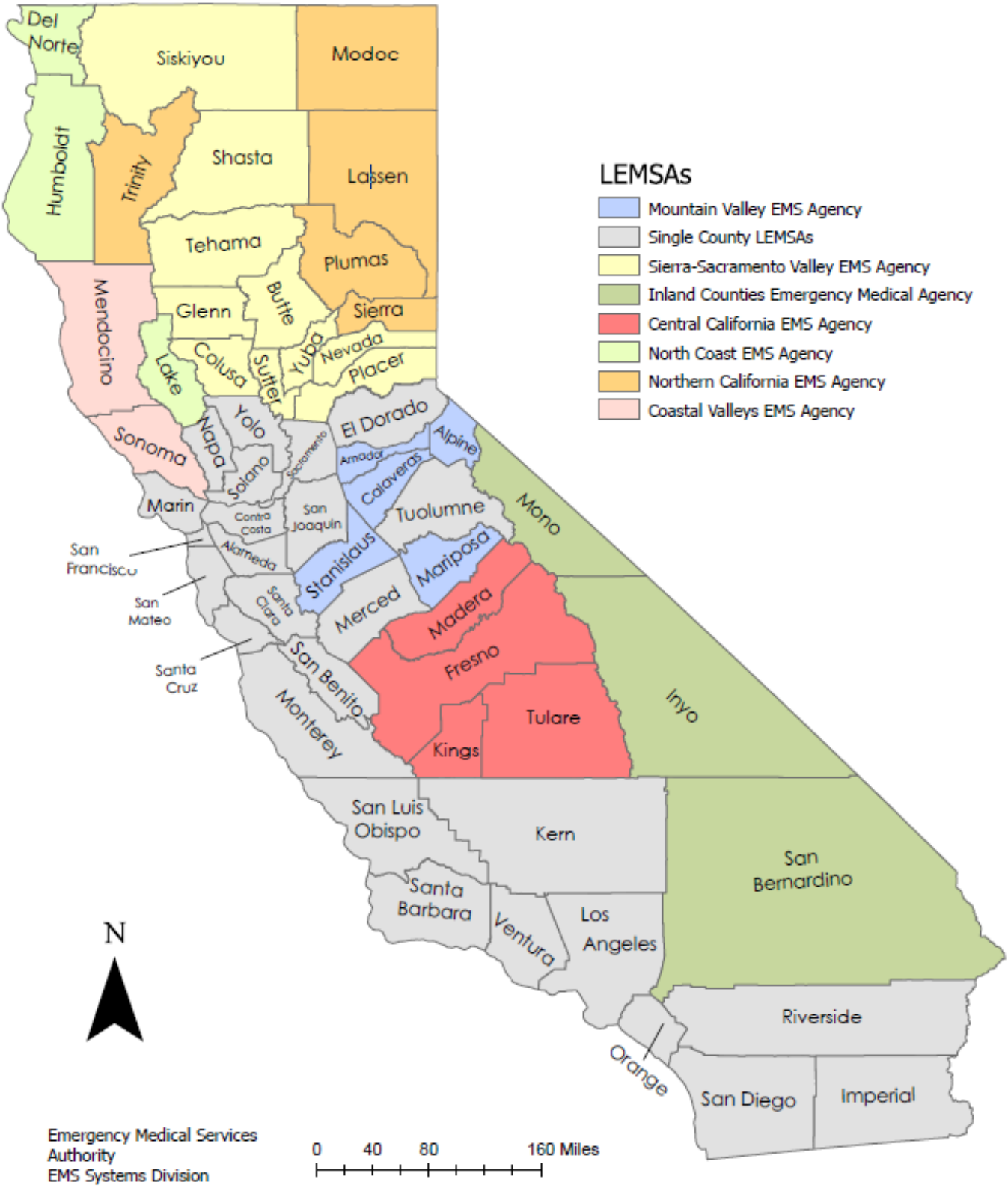
Maps of Matched Records using ArcGIS Pro™

The following is a series of maps depicting different aspects of this report to demonstrate that the EMS Authority can visualize our data from CEMSIS and the Patient Trauma Registry using geospatial software such as Esri's ArcGIS Pro™. Data were obtained from 32 out of 33 LEMSAs and are depicted in the subsequent maps. Los Angeles County EMS Agency's EMS data did not populate for this project's timeframe; thus, they were excluded. The data and LEMSA designation are based on 2019 values and criteria and do not reflect any LEMSA changes that have been made since 2019.

The list of maps is as follows:

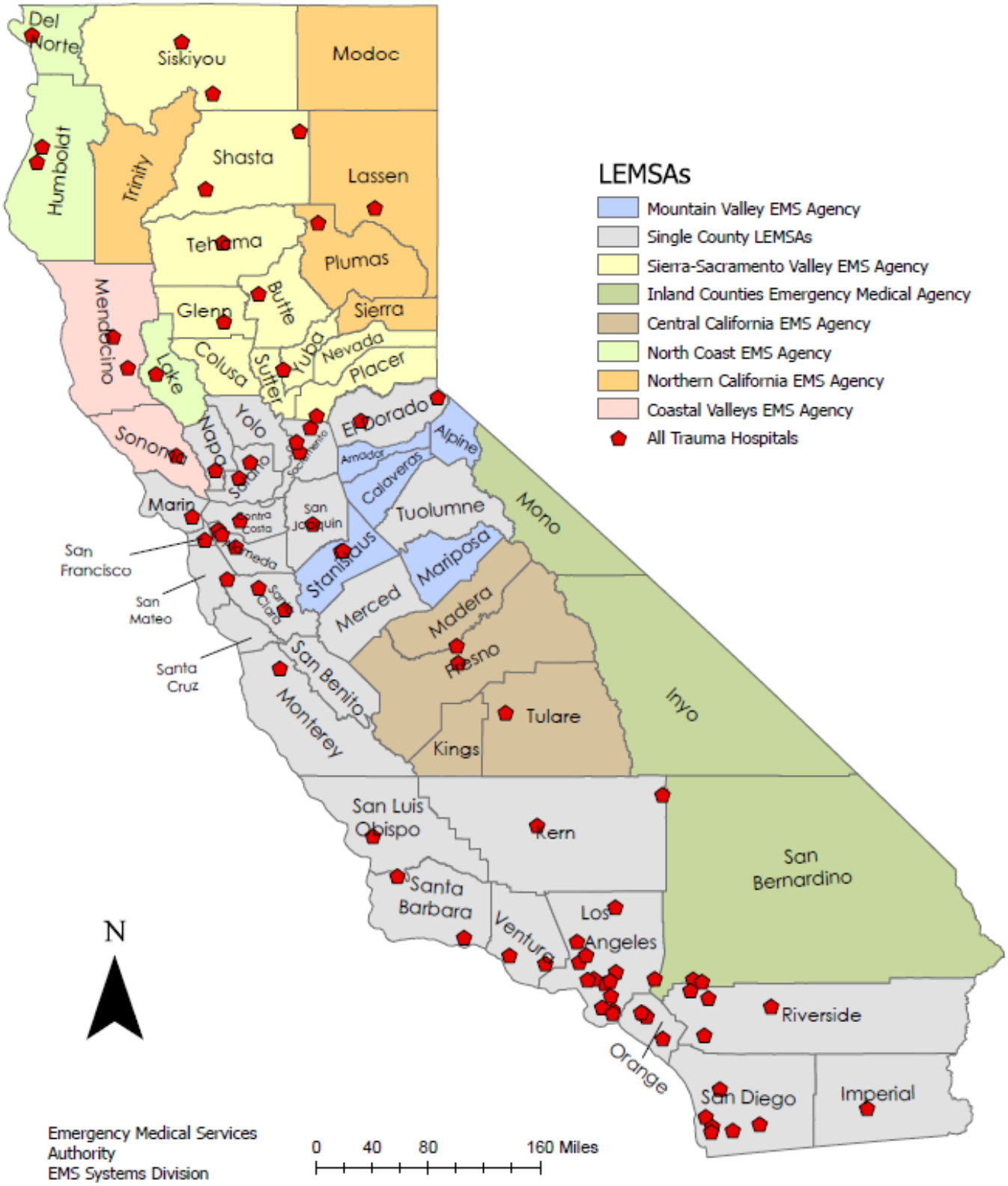
1. Single and Multi-County LEMSAs in California
2. All designated trauma centers
3. Designated trauma centers with levels
4. Matched or unmatched records from trauma centers
5. Match rate category by percentage
6. Multi-County LEMSA match rates
7. Single-County LEMSA match rates

LEMSAs in California for CY 2019

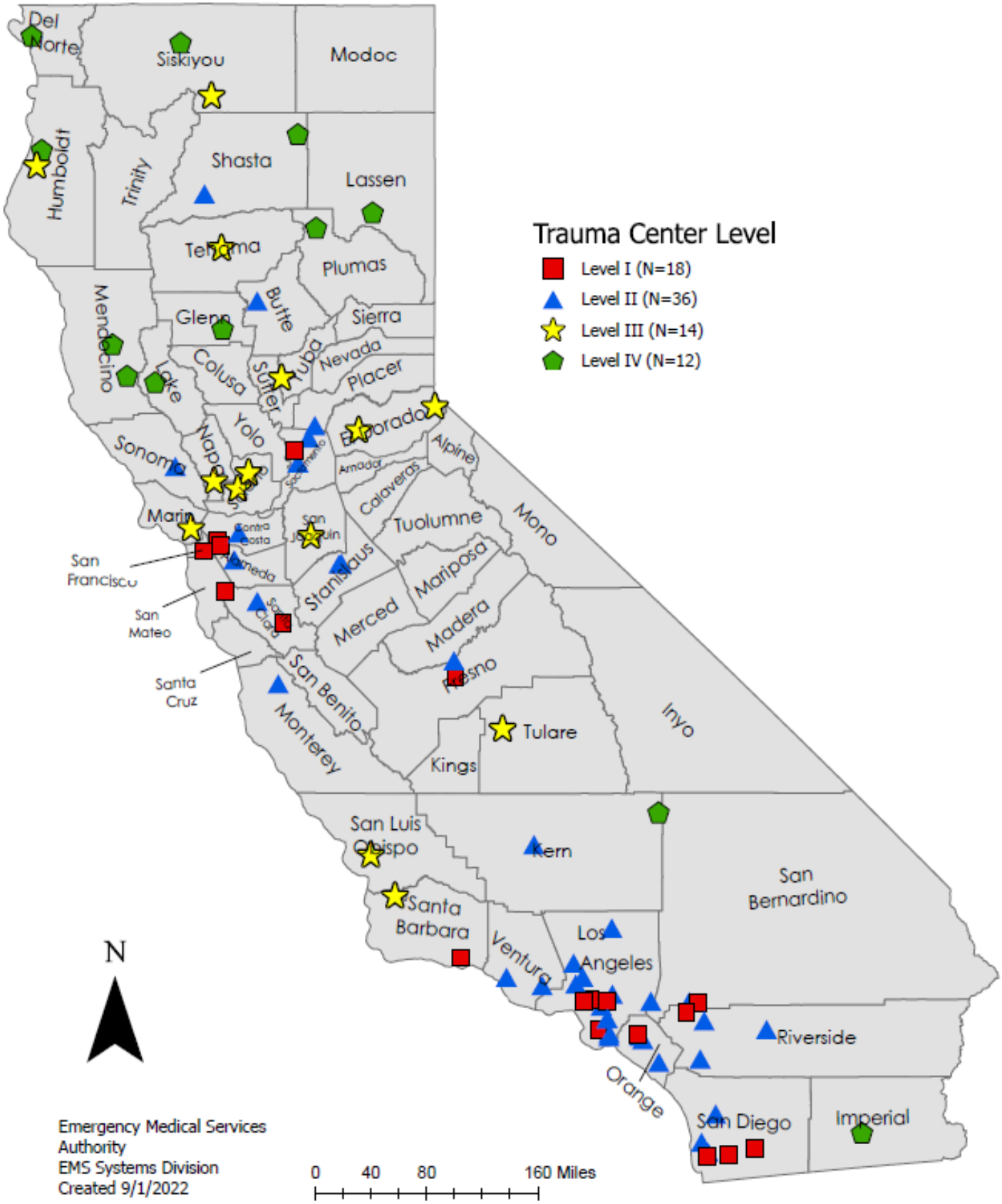


8.

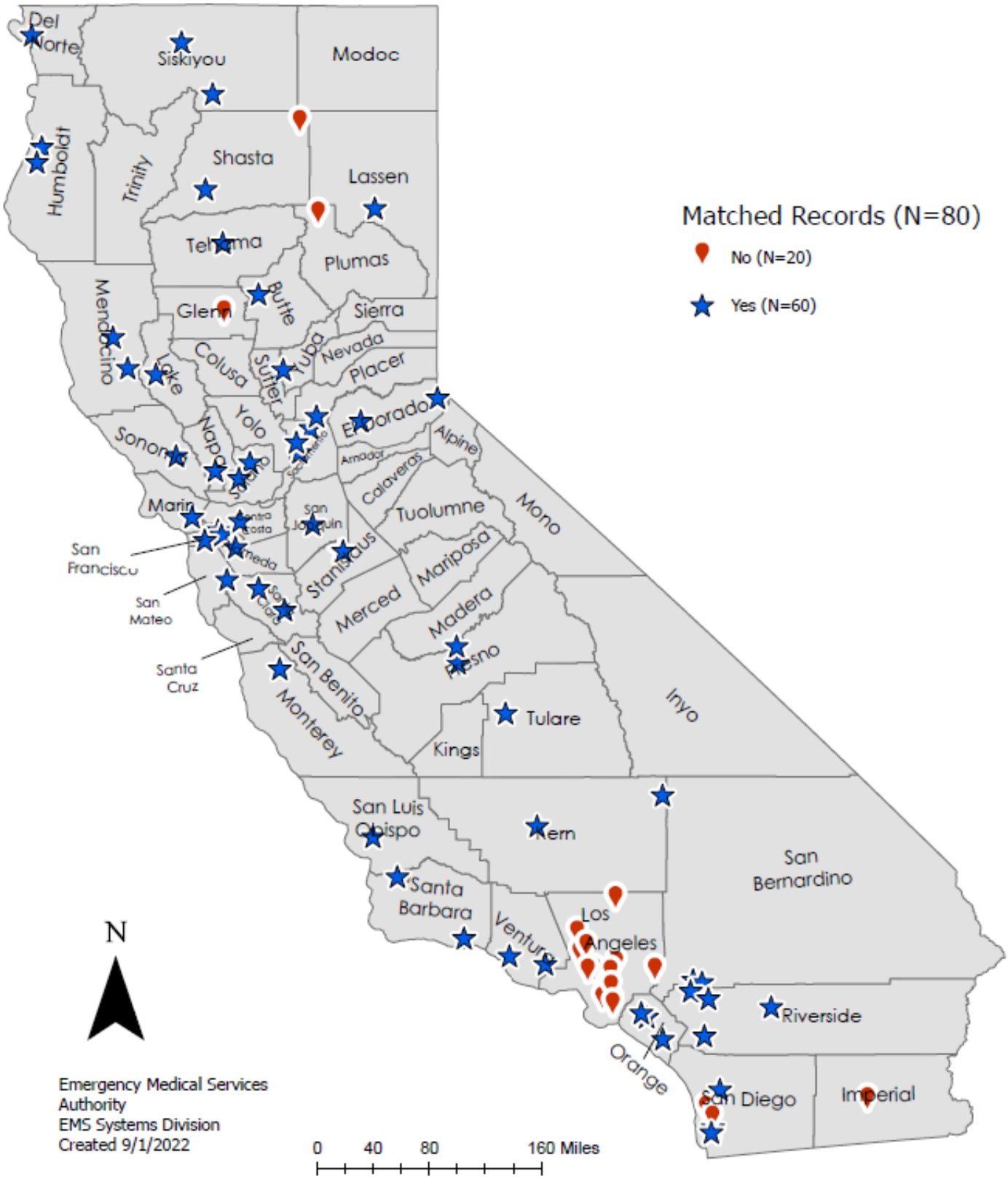
All Designated Trauma Centers in California for CY 2019



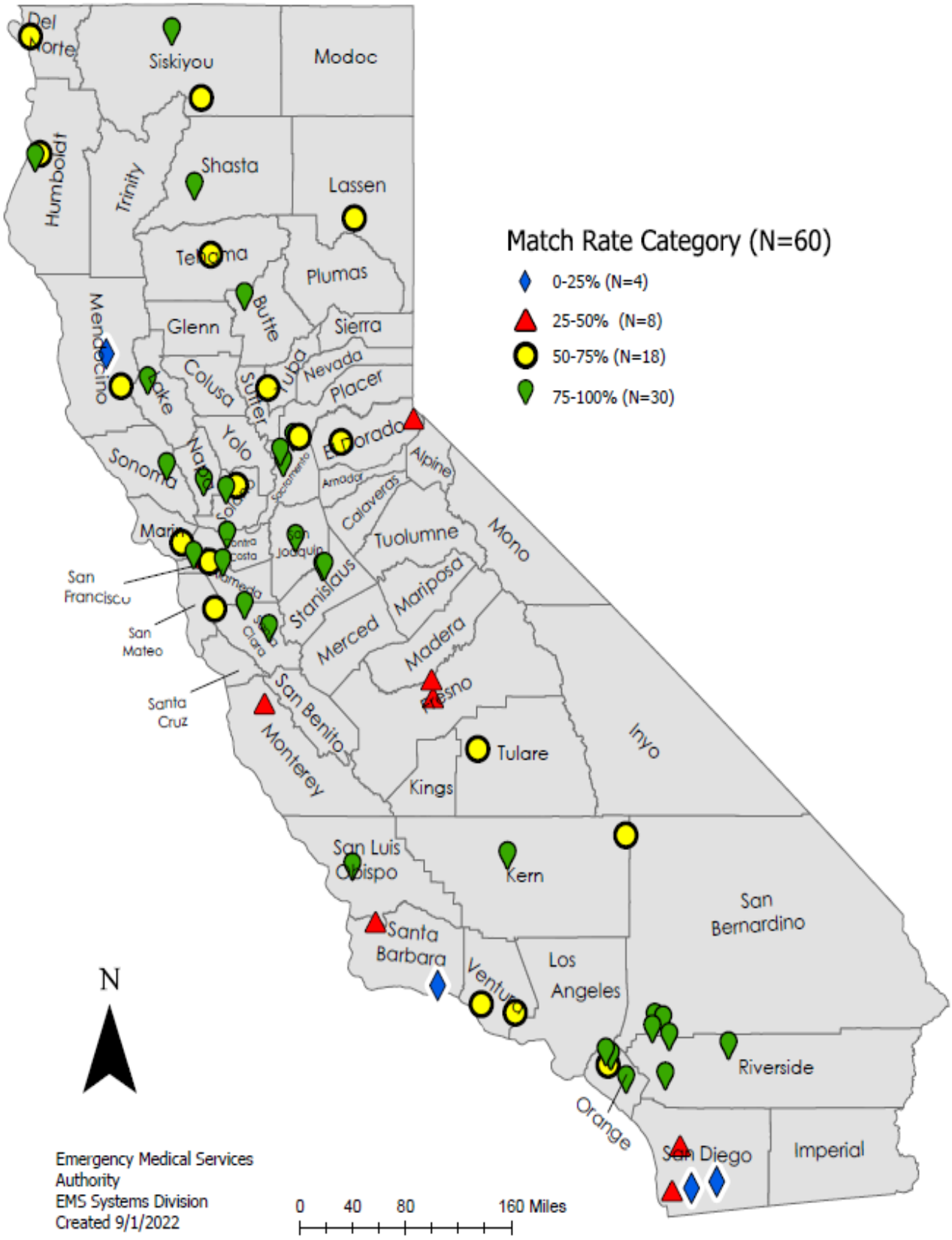
Designated Trauma Center Levels in California for CY 2019



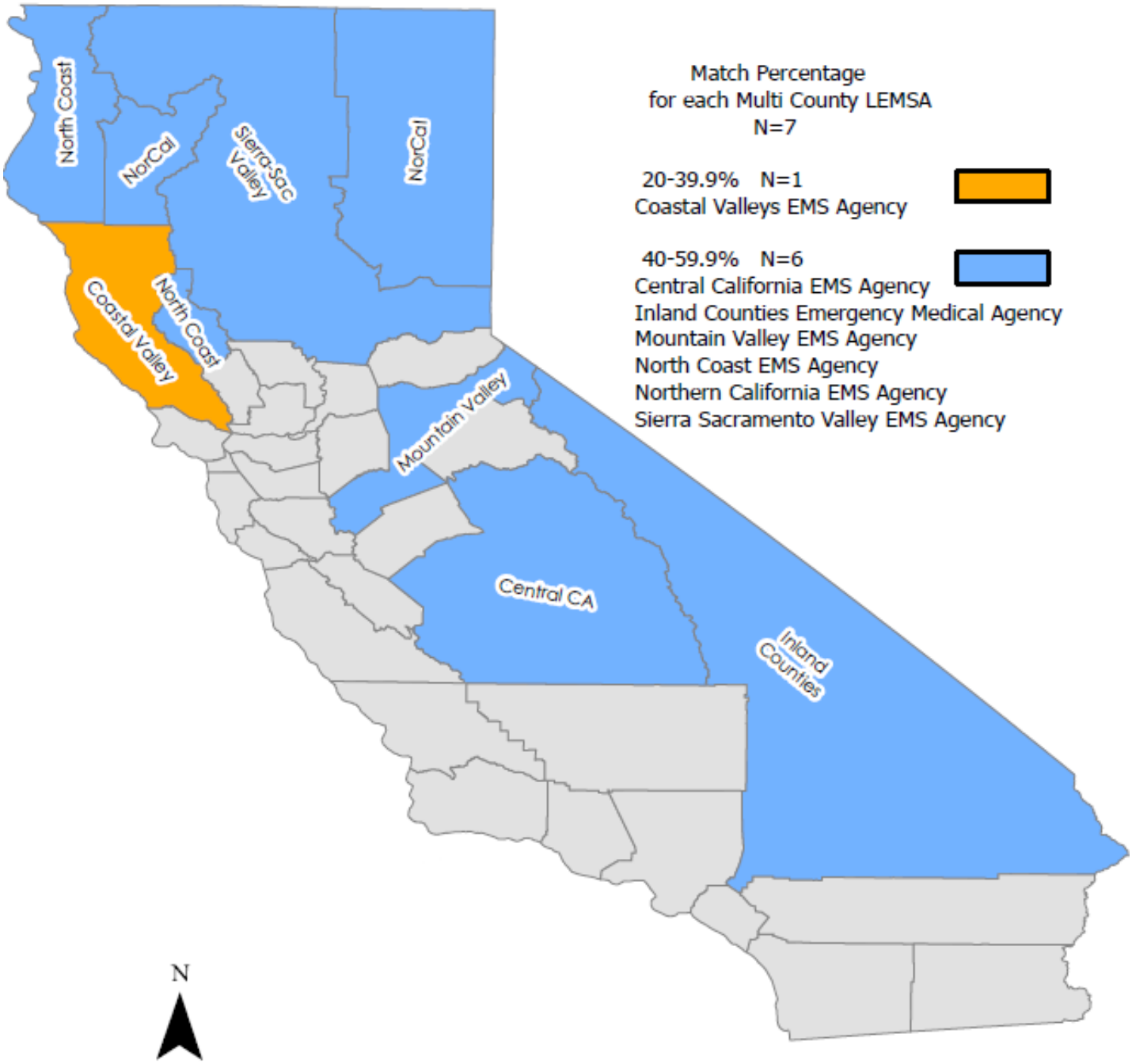
Matched and Unmatched Records of Designated Trauma Centers in California for CY 2019



Match Rate Category by Percentage in California for CY 2019



Multi-County LEMSA Match Rates with Trauma Hospital Records in CY 2019



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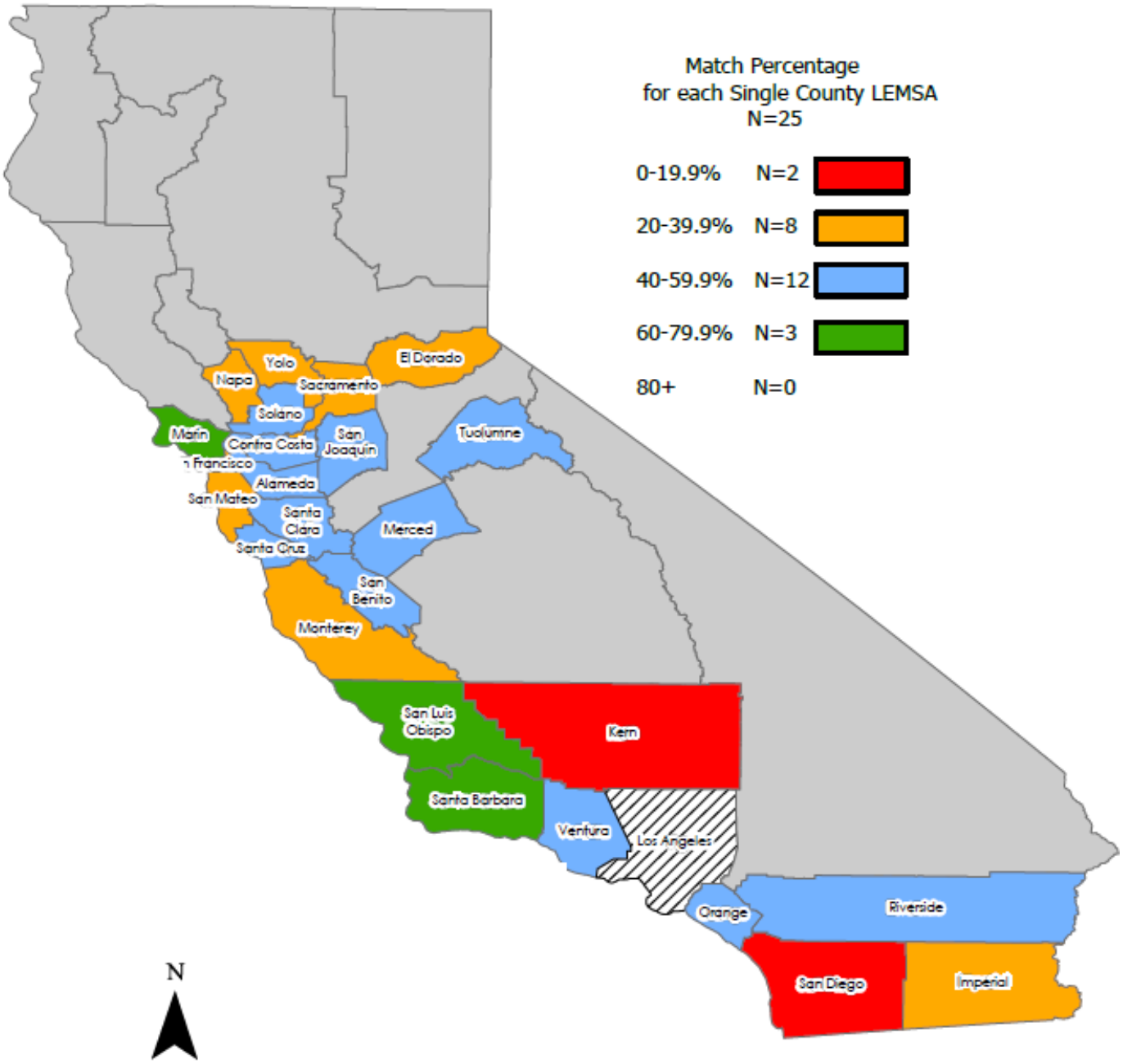
Single County LEMSA Match Rates with Trauma Hospital Records in CY 2019



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0 48.5 97 194 Miles

Discussion and Conclusion

Linking trauma and prehospital records for the same patient is warranted and effective as shown in previous studies other researchers in the EMS field have done. Again, these findings were indicated in the previous report.

The results produced a better overall picture of each patient from the beginning of an emergency to the result when they leave the hospital. The successful match rate (69%) of EMS and trauma patient hospital records was comparable to other studies that the EMS Authority identified and 5% higher match rate than was done in the previous data-matching study for Riverside Community Hospital and 11% higher than the EMS Authority's original matching attempt for UC Davis Medical Center (58%). Several other researchers' attempts at data linkage had similar results with an average of 50-70% match rates. Without unique identifiers, like a patient's full name or Social Security number, it is improbable that a 100% match rate will occur. There are also technical issues with recordkeeping systems and data entry errors that are common. Still, a 69% match rate can produce beneficial information about a given population.

Challenges to completing the objectives included: absence of unique identifiers across multiple databases (ImageTrend Elite and Patient Registry). There may also be missing, and inaccurate data entered in these databases posing significant restrictions on data matching efforts. This report analyzed the entire matched record amount for fall injuries, but the original criteria did not limit to falls specifically. This would have yielded a vast undercount because every EMS agency and provider documents patient information differently. Therefore, it is unhelpful for these reports to delimit the data elements to only include "falls" criteria. However, the subsequent report will focus on the outcomes of using limiting criteria on EMS data and how that affects matching records in the patient registry.